Space Weather Technical Forecast

Issued on Tuesday, 01 August 2023 at 01:23 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: R1-R2 Blackouts likely, with a chance of R3. CME arrival expected day 1 (01 Aug) with G1-G2 Minor/Moderate Storm possible.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with one M-class flare, reaching M1.6 at 31/0900 UTC from AR3390 in the southeast. This is a small and unremarkable region, but has been the source of a number of recent low-level M-flares. There are now eleven sunspot regions on the disc, with AR3380 in the southeast the most notable, having shown significant growth and increased complexity. This is due to flux emergence on its northern periphery, resulting in the developing of a strong delta spot with ongoing growth occurring. AR3393 near the east limb is the only other region showing notable growth, however this appears to have stablised into a simple configuration as a series of smaller spots. AR3386 persists as a moderately sizes region in the north-centre disc, but has been slowly simplifying. All other regions are smaller and simpler.

No new Earth-directed CMEs have been observed in the last 24 hours, however a dsf (disappearing solar filament) occurred in the centre disc from 31/1800 UTC. The required coronagraph imagery to assess any potential for CME from this dsf has yet to become available.

Solar Wind / Geomagnetic Activity: The solar wind showed a transition from fast wind environment into the slow wind. L1 speeds, as observed by ACE, quickly eased from slightly elevated speeds, near 500 km/s, to persist at background, 350-420 km/s since 31/0100 UTC. Density was below average. The total interplanetary magnetic field strength (Bt) remained weak, below 6nT, with the north-south component also weak but predominately negative (southward) ranging from -6nT to +3 nT. Phi angle remained mainly positive (away from the Sun). Geomagnetic activity was Quiet (Kp 0-2).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton remained slightly above background levels with peak 2.9pfu but declining, and well below the S1 Minor Storm level. GOES16 high energy (greater than 2MeV) electron flux varied from Background to Moderate levels at the diurnal maximum, peaking at 935 pfu at 30/1615 UTC. The associated 24-hour integrated fluence remained below the Active level (1e8 integrated pfu), with 4.14e7 integrated pfu was recorded at 31/2100UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Activity is likely to be Moderate, with a chance of rising to High. This is mainly due to the increased potential for M-flares, along with a chance of X-flares, from AR3380 on the southwest disc.

Solar Wind / Geomagnetic Activity: The CME from a filament eruption on 29 Jul is currently forecast to arrive at 01/1000 UTC +/- 9 hours. Solar winds then likely easing to background later day 2 (02 Aug). There is a potential for further coronal hole sourced enhancements late day 3 or day 4 (03-04 Aug) from either CH31/- or a further unnumbered CH/+ in the centre disc, however both these features are low confidence as they are difficult to observe in SDO imagery. Geomagnetic activity is expected to be Quiet before the CME arrival, increasing to Active to G1/Minor Storm as it arrives with a chance of G2/Moderate Storm intervals. These conditions

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easing day 2 to mostly Quiet with isolated Unsettled intervals. Any further solar wind enhancement day 3 or day 4 bring further Unsettled to Active intervals with a slight chance of G1/Minor Storms.

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux is now below the S1 level, and is likely to continue easing to background levels. There is a slight chance of a further enhancement to S1 with the CME arrival on Day 2 (01 Aug), before returning to background. There is also a slight chance of further enhancement from any other notable flares that occur, mainly from AR3380. The high energy electron flux (greater than 10 MeV) is likely to drop out with the anticipated CME arrival on Day 1 (01 Aug), before rising again to Moderate, perhaps High (1000 pfu) at diurnal maximum day 2 (02 Aug) onward. Any further enhancement day 3 or 4 (03-04 Aug) will likely lead to a further drop out in values. The associated fluence is most likely to remain below the Active threshold (1e8 total pfu), but with a rising trend from day 2 once any CME influence subsides.

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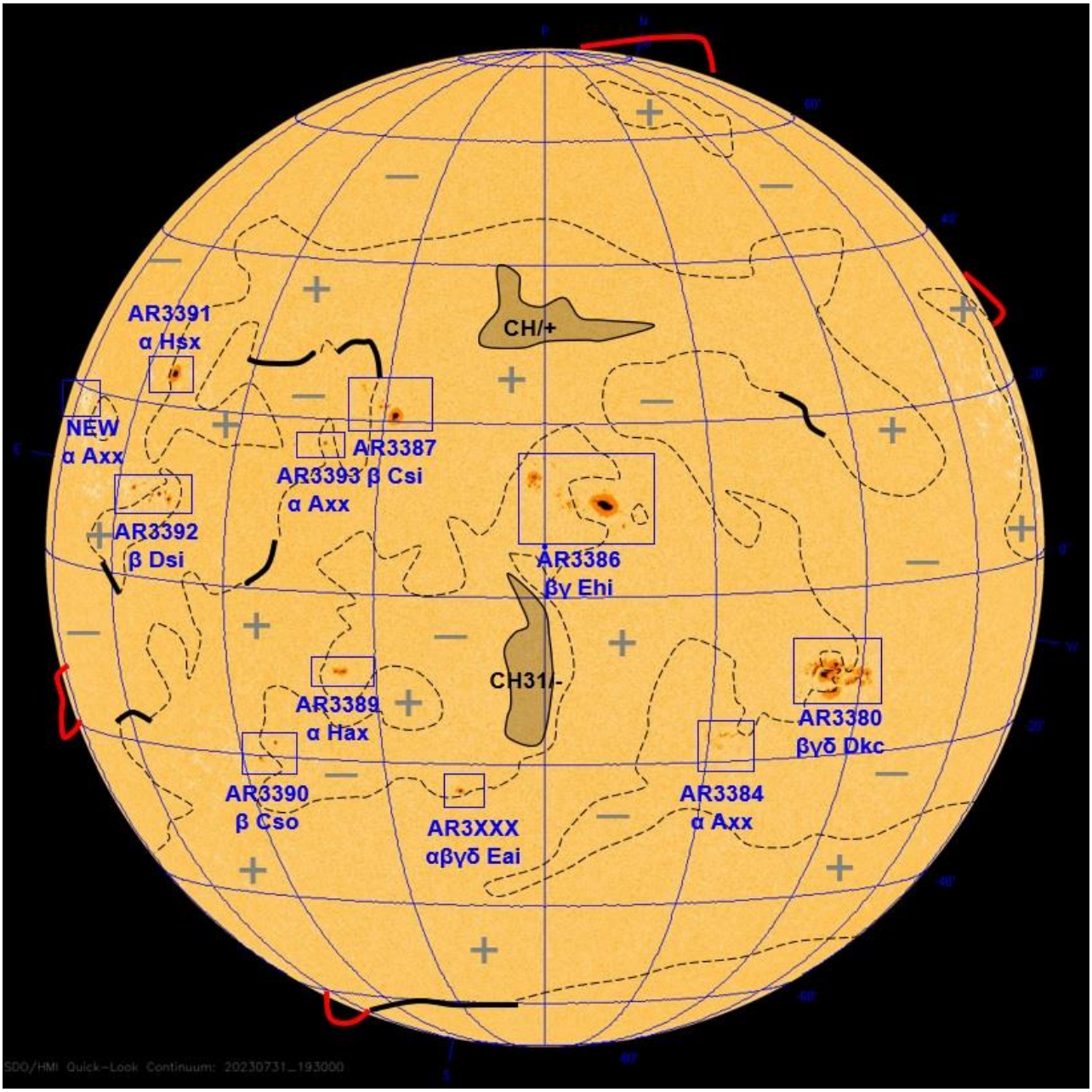
Figure 1. Solar Analysis Valid 31/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There is one Earth-directed CME, due to a filament eruption from the northeast quadrant on 29 Jul. This is currently forecast to arrive at 01/1000 UTC +/- 9 hours. This has yet to be seen on STEREO A, which is currently position near 0.95 AU, inside of Earth's orbit, and due to this likely to observed any arriving CME around 4-5hours before Earth, depending upon the speed of the CME. A dsf (disappearing solar filament) was observed on both SDO and H-alpha imagery from the centre disc around after 31/1800 UTC. Coronagraph imagery has yet to become available to assess the likelihood of any Earth-directed CME.

Otherwise solar winds have now eased to background after recent coronal hole enhancement. Once CME influence recedes day 2 (02 Aug), the next enhancement is likely from either CH31/- or an unnumbered CH/+ in the north-centre disc. Both these features are low confidence however as they are largely obscured in imagery, but are coincident with larger and much clearer coronal holes on the previous 27-day rotation. Any enhancement is expected to be either late day 3 or more likely day 4 (03-04 Aug).

Geomagnetic activity is expected to be Quiet before the CME arrival, then increasing to Active to G1/Minor Storm as it arrives. There is a chance of G2/Moderate Storm intervals. These conditions easing day 2 (02 Aug) to become mostly Quiet with isolated Unsettled intervals. Any further solar wind enhancement late day 3 or day 4 (03-04 Aug) will bring further Unsettled to Active intervals with a slight chance of G1/Minor Storms.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	70	20	5	10
Strong	G3	No	10	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
29/0550	Partial	Filament	NE	505 km/s	27/1000 +/- 9hours	Nil.

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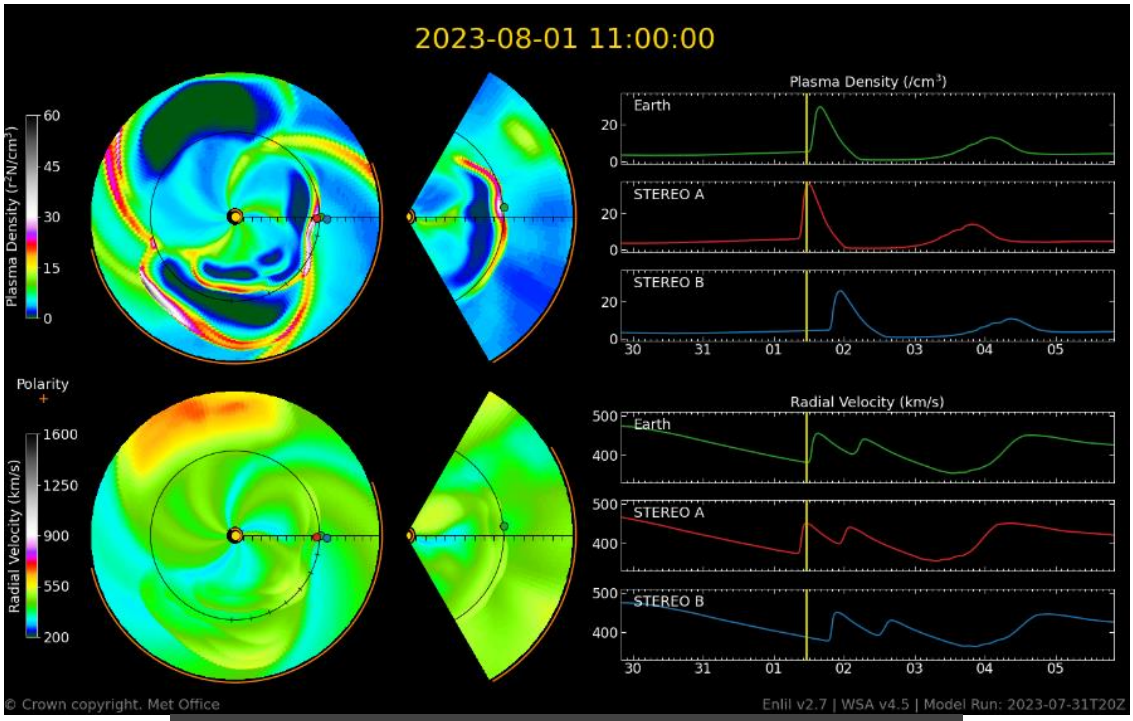
Figure 2a: Enlil showing expected solar wind arrival with ensemble



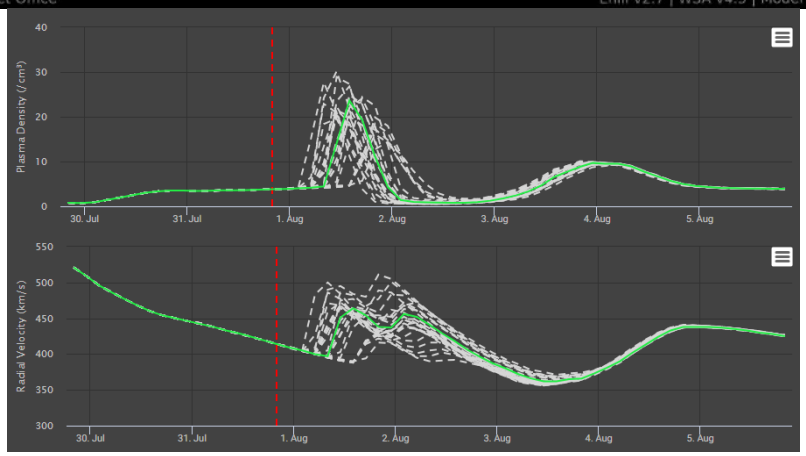
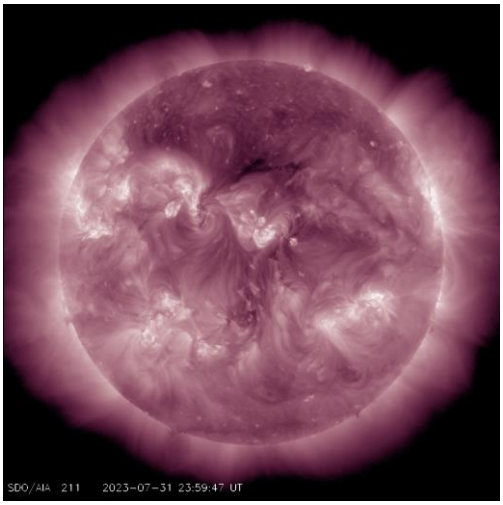


Figure 2b: SDO aia-211 with any coronal holes difficult to observe.



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Radio Blackouts - X-Ray Flares:

There are currently eleven sunspot regions on the disc with Moderate activity. Despite its relatively simple appearance, AR3390 in the southeast has been the most active of the regions with an M1.6 flare.

The most significant region however is AR3380 in the southwest. This has shown notable growth on its northern extent, developing into a moderately sized and compact region with at least one delta spot. The main, and strongest delta spot is a narrow positive umbra and penumbra region, sandwiched between two negative polarity penumbra, with one of these also containing a strong umbra. This is a potentially unstable setup, and if any magnetic reconnection occurs, significant flares are possible giving a likelihood of M-flares and a chance of X-flares.

Of the other regions on the disc, the only ones of note are the moderately sized AR3386 in the centre north disc, and developing AR3393 in the northwest. The former, however, has remained stable with no activity observed, despite some slight complexity. The latter rapidly emerged in the last 24 hours but now appears to have separated into a relatively simple configuration.

There is also the potential for a returning region to rotate onto the southeast limb during day 2 (03 Aug). This would be returning notable region AR3363, and corresponds to a strong signal in far-side products. However there is low confidence for how much of this region remains from its far-side transit.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	75	75	70	70
Very Active	R3 to R5 X Class	No	25	25	20	20

Figure 3a: GOES-16/18 X-ray Flux

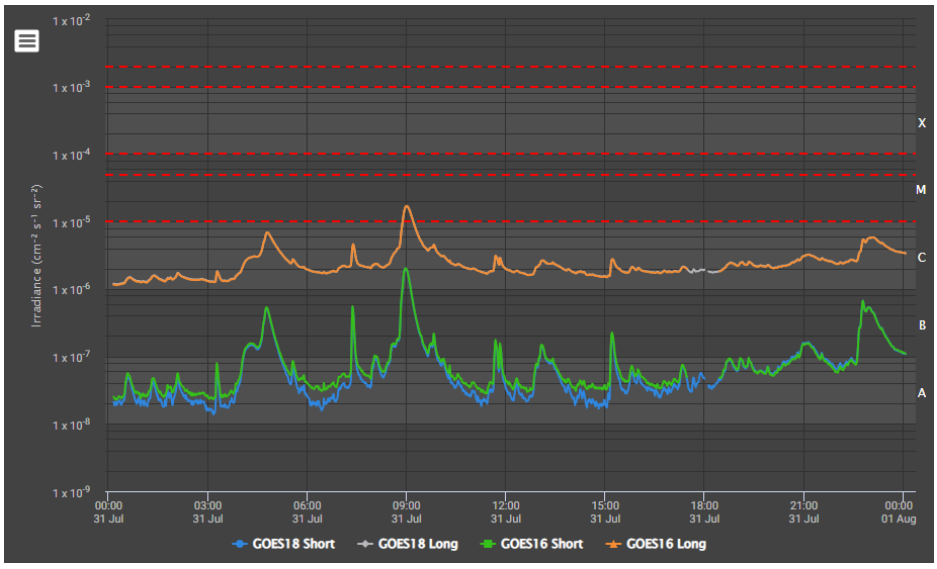

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Figure 3b: AR3380 SDO Intensitygram (left) and Magnetogram (right), showing strong delta spot (circled

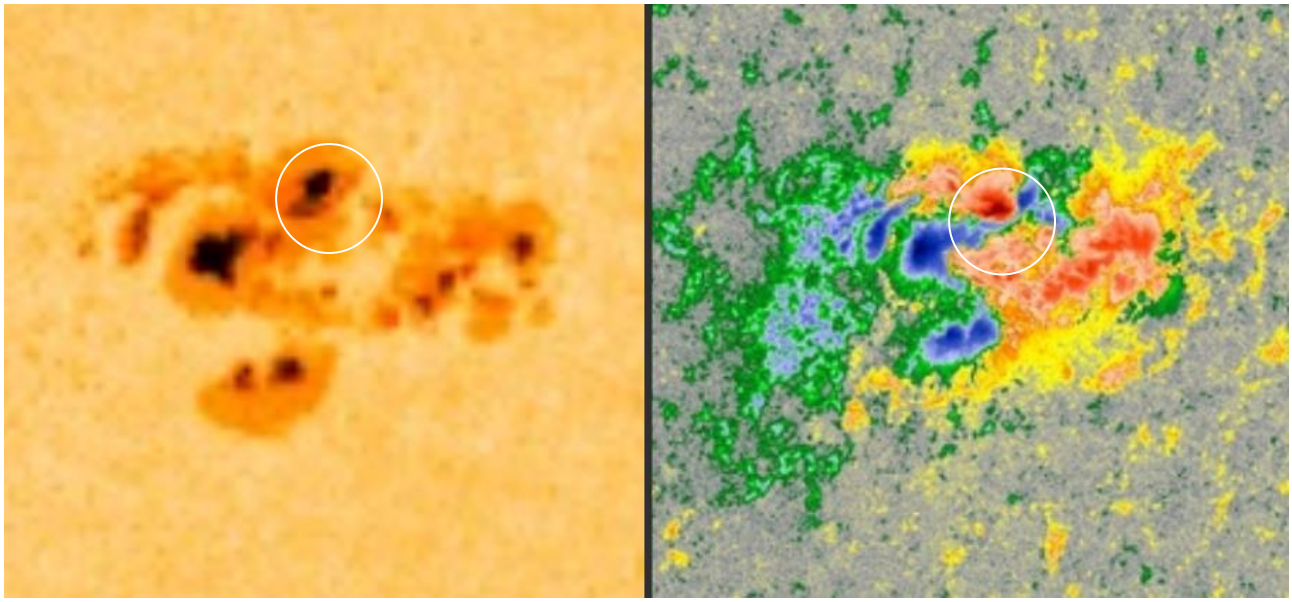
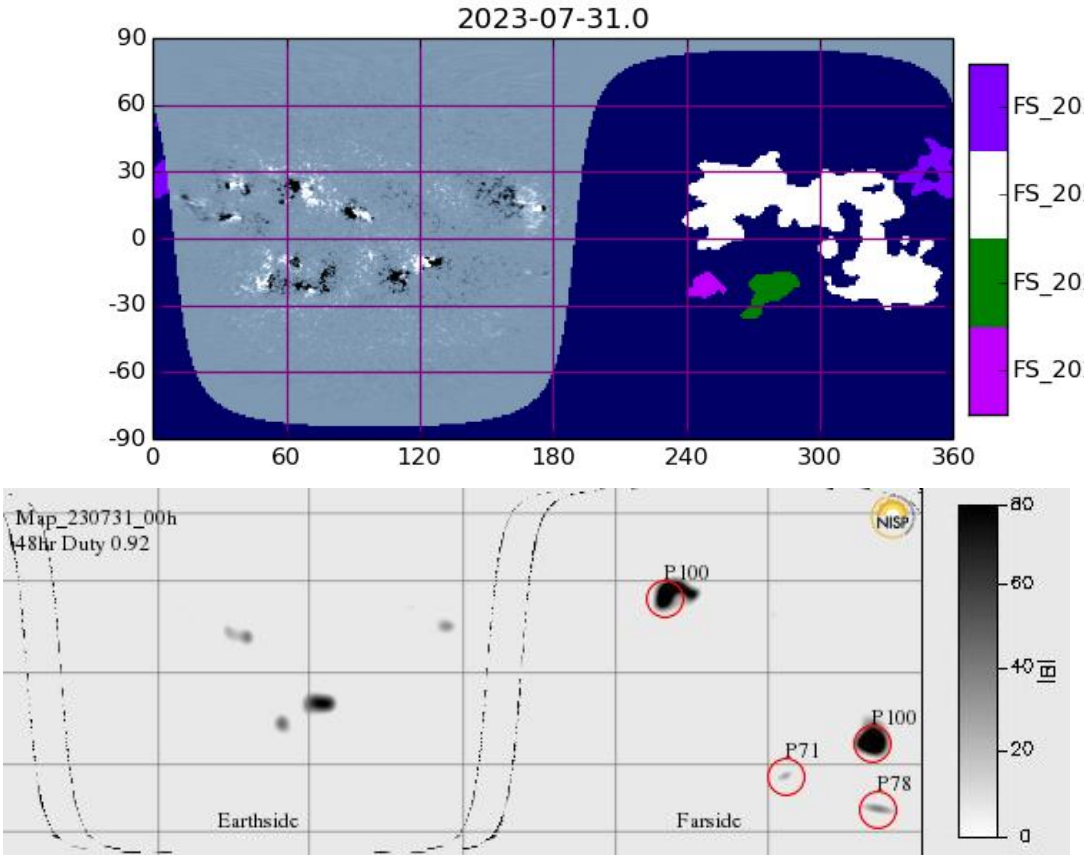


Figure 3c: Far-side imagery from jsoc.stanford.edu (top) and far-side GONG imagery (bottom) showing strong signal for ex AR3363 to return



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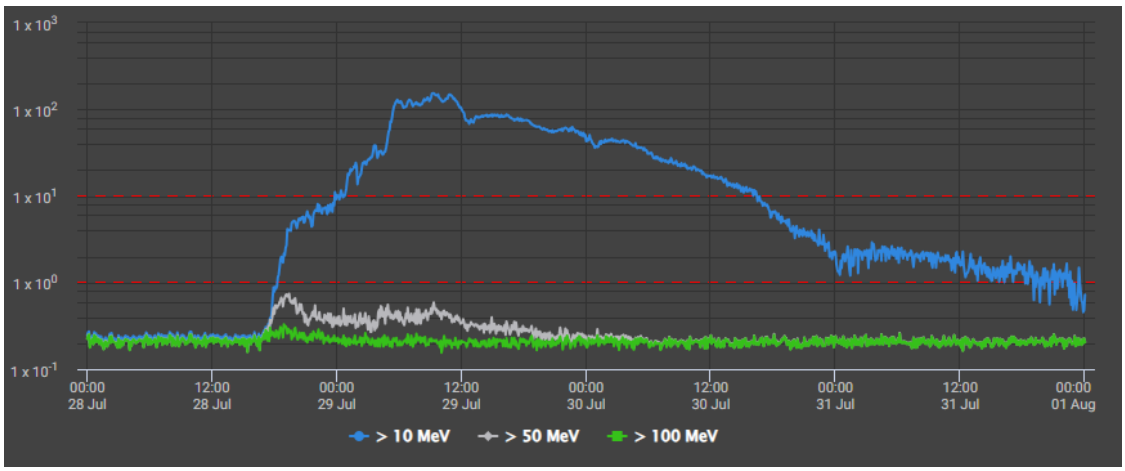
Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux is below the S1 Minor Storm level, but currently slightly above background as it recovers from the 28 Jul far-sided eruption that brought an S2 Moderate Storm on 29 Jul.

The CME arrival forecast day 1 (01 Aug) has a chance of increasing flux as it arrives, but likely staying below S1. Otherwise the main risk of further proton storms is from the growing and increasingly complex sunspot region AR3380 in the southwest disc. Any significant flares from this region will bring a chance of further increases in proton flux, with a slight chance of exceeding S1/Minor Storm.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	15	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES-16 >10 MeV, >50MeV and >100 MeV Proton flux since 28 Jul (top red dashed line is S1 level)



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High Energy Electrons Event (≥ 2MeV):

High energy (greater than 2 MeV) electron flux observed by GOES-16 is currently Background to Moderate, and likely to drop out to background at GEO with the CME arrival on day 1 (01 Aug). As any subsequent solar wind pressure eases day 2 (02 Aug) flux observed at this level is expected to rise to Moderate, with a chance of reaching High, mainly at diurnal peak periods. The next drop out of any observed flux is likely to be with a transition into the fast winds of CH31 and a further northern disc coronal hole either late day 3 or day 4 (03-04 Aug), however this is currently low confidence.

The associated 24 hour fluence is forecast to remain below Active (1e8 total pfu) but with a slight chance of rising above, mainly on day 3 (03 Aug) before any subsequent enhancement from either of the low confidence coronal holes. REFM is currently giving a good guide to background conditions in the absence of any CME arrival, however will become less useful once this occurs on day 1 (01 Aug).

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	10	20	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: GOES 16 >2MeV electron flux (top) and fluence with REFM and Recurrence (bottom)

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